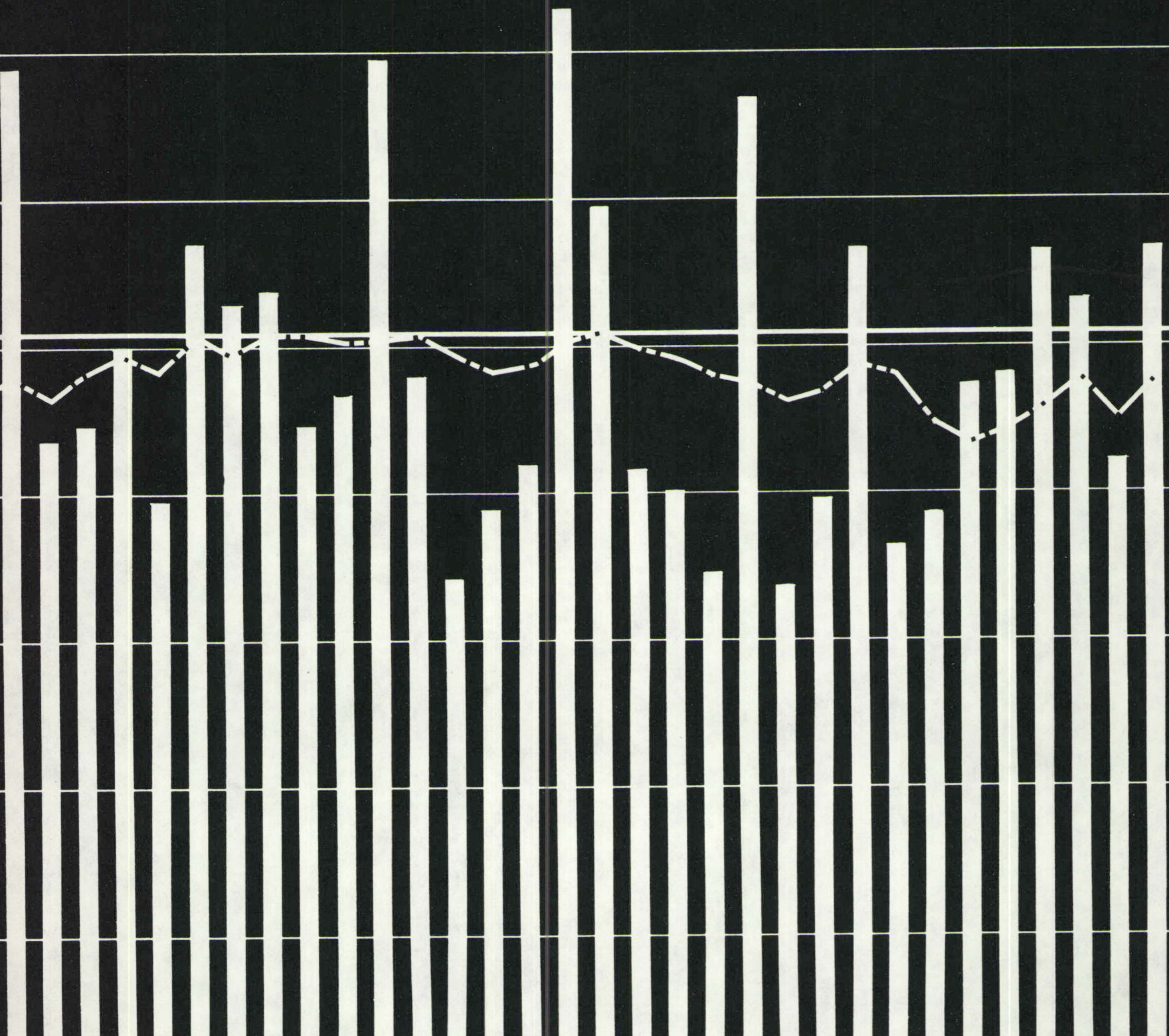
WATER FOR OIL SHALE WHITE RIVER UINTAH COUNTY, UTAH



prepared for

STATE OF UTAH

Division of Water Resources

Bingham Engineering

CONCLUSIONS

A multipurpose dam and reservoir on the White River is the preferred method of providing water for oil shale development for the following reasons:

1. Without in basin storage, or an imported supply of water, development of land and mineral resources in the White River Basin requiring a firm water supply will be precluded. (Indian lands in Utah have priority rights to White River water during low flow periods)

2. A reservoir would provide greater regional economic impact in that it could provide water for oil shale development near the White River other than at lease tracts U-a and U-b and also provide a firm water supply for expanded irrigation on both Indian and fee lands near the mouth of the river.

3. The dam and reservoir could provide water to oil shale lease tracts U-a and U-b at less cost than the other alternatives.

4. Construction of a dam on the White River should create both a reservoir and stream fishery where only a poor one at best now exists. Water based recreational opportunities in the area will be enchanced.

5. More electrical energy will be consumed in providing water to lease tracts U-a and U-b through other alternative methods than through construction of a dam and reservoir with related pumping facilities on the White River. The reservoir in fact offiers the opportunity for generating hydroelectric power.

6. The dam and reservoir should alleviate sediment problems and reduce the number of damaging floods in the river. It will also help to insure a more uniform quality of water.

7. The Utah Board of Water Resources has recognized the potential public benefits that could accrue through development of storage on the White River and have endorsed the concept of a dam and reservoir on the river to fulfill the water needs of oil shale development.

It is recognized that construction of a dam and reservoir on the River will inundate some desirable habitat for big game and other wildlife.

WHITE RIVER DAM AND RESERVOIR SUMMARY

LOCATION NE 1/4 SEC. 17 SITE #2A
T. 10 S., R. 24 E.

ELEVATION, TOP OF DAM	(FEET)	5020
ELEVATION, SPILLWAY CREST	(FEET)	5010
HEIGHT ABOVE STREAM BED	(FEET)	125
LENGTH OF DAM ALONG CREST	(FEET)	2480
VOLUME, DAM EMBANKMENT	(CU. - YD)	1,700,000
PRINCIPAL SPILLWAY CAPACITY	(CFS)	17,200
EMERGENCY SPILLWAY CAPACITY	(CFS)	41,500
OUTLET CAPACITY	(CFS)	1,300
RESERVOIR CAPACITY	(AC.-FEET)	118,000
AREA, NORMAL HIGH WATER SURFACE	(ACRES)	1,810
LENGTH OF RESERVOIR	(MILES)	12
MAX. WIDTH OF RESERVOIR	(MILES)	0.8

PROJECT BENEFITS

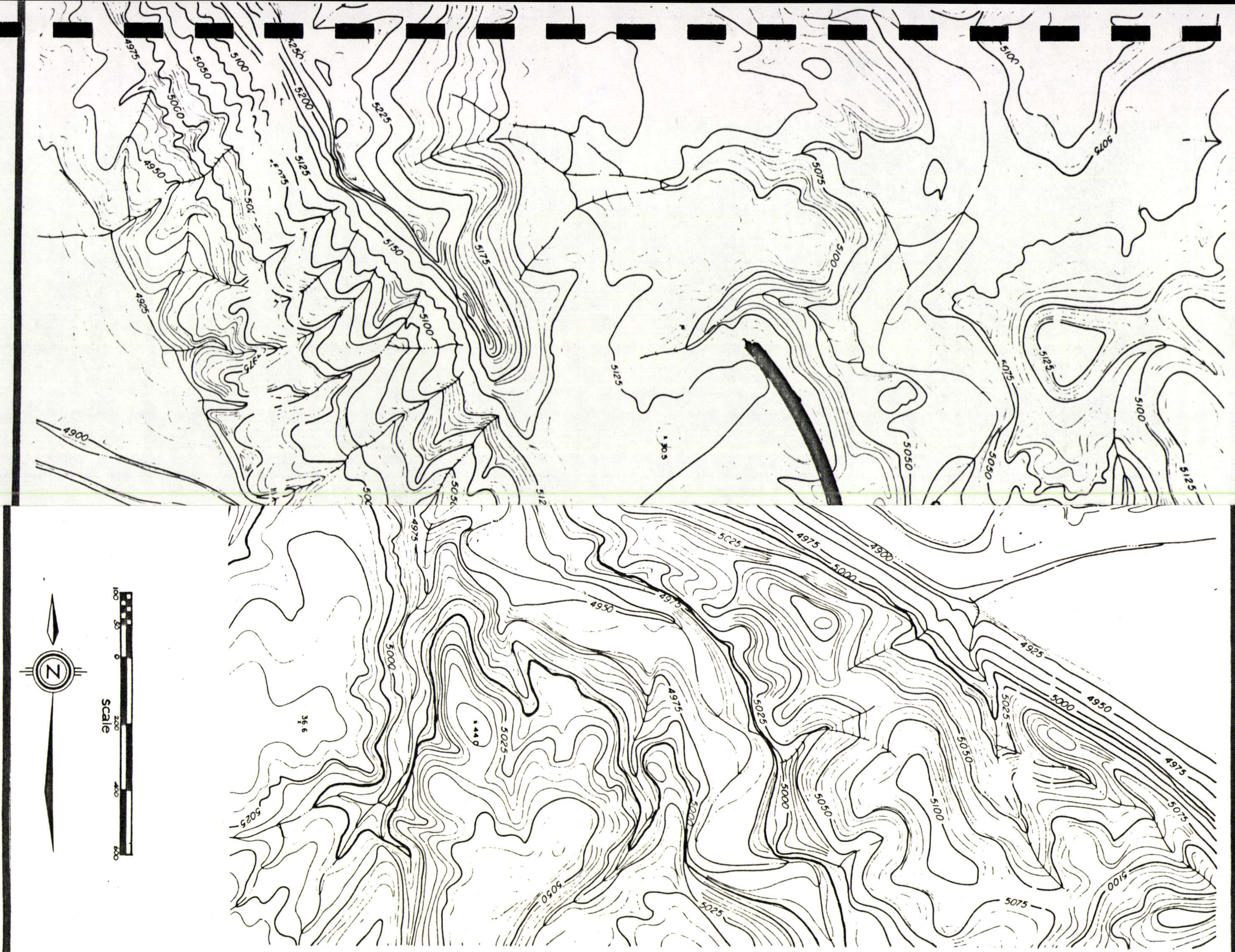
OIL SHALE SUPPLY 26,000 AF/YR+
IRRIGATION SUPPLY

6000+ ACRES @ 4 A.F./AC. = 24,000+
60 ACRES/CFS = 100 CFS
(LOW FLOW 1934 52 CFS. STORAGE WOULD SUPPLEMENT FLOW)

REDUCE SEDIMENT

MORE UNIFORM QUALITY

REDUCE FLOOD PEAKS FROM SUMMER FLASH FLOODS - MINIMIZING DISRUPTION TO IRRIGATION SYSTEMS.



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WHITE RIVER DAM
GENERAL PLAN

FIGURE 13

WATER FOR OIL SHALE

INTRODUCTION

Utah's oil shale resources constitute a significant potential source of energy to meet dwindling oil supplies in the United States. As with most other forms of energy resource development, oil shale will require a large amount of water to serve the various processes and support facilities needed to economically produce a final, useable product. Where water supplies are limited, both physically and legally, as they are in Utah; it is incumbent that careful water use planning be made to insure that the uses are compatible with over-all state goals.

Accordingly, the Utah State Division of Water Resources requested Bingham Engineering to study the potential for development of water storage facilities on the White River in Uintah County to meet the water needs for oil shale development. The initial concept of this study directed the investigative efforts toward a single purpose water development project to satisfy water needs of the potential oil shale industry. As the study progressed, it became apparent that water development on the White River could satisfy a broader need and that greater economic and environmental benefits could be achieved. For example, the Ute Indian Tribe has a large tract of irrigable acreage near the junction of the White and Green Rivers. Some of this land is now being cleared and put into production by private leasees. Stabilization of River flows would enhance this enterprise as well as permit more economical expansion. Development of some hydro-power potential also appears feasible as discussed later in this report. Stabilization of river flows and reduction in sediment loads should offer an opportunity for fishery improvement.

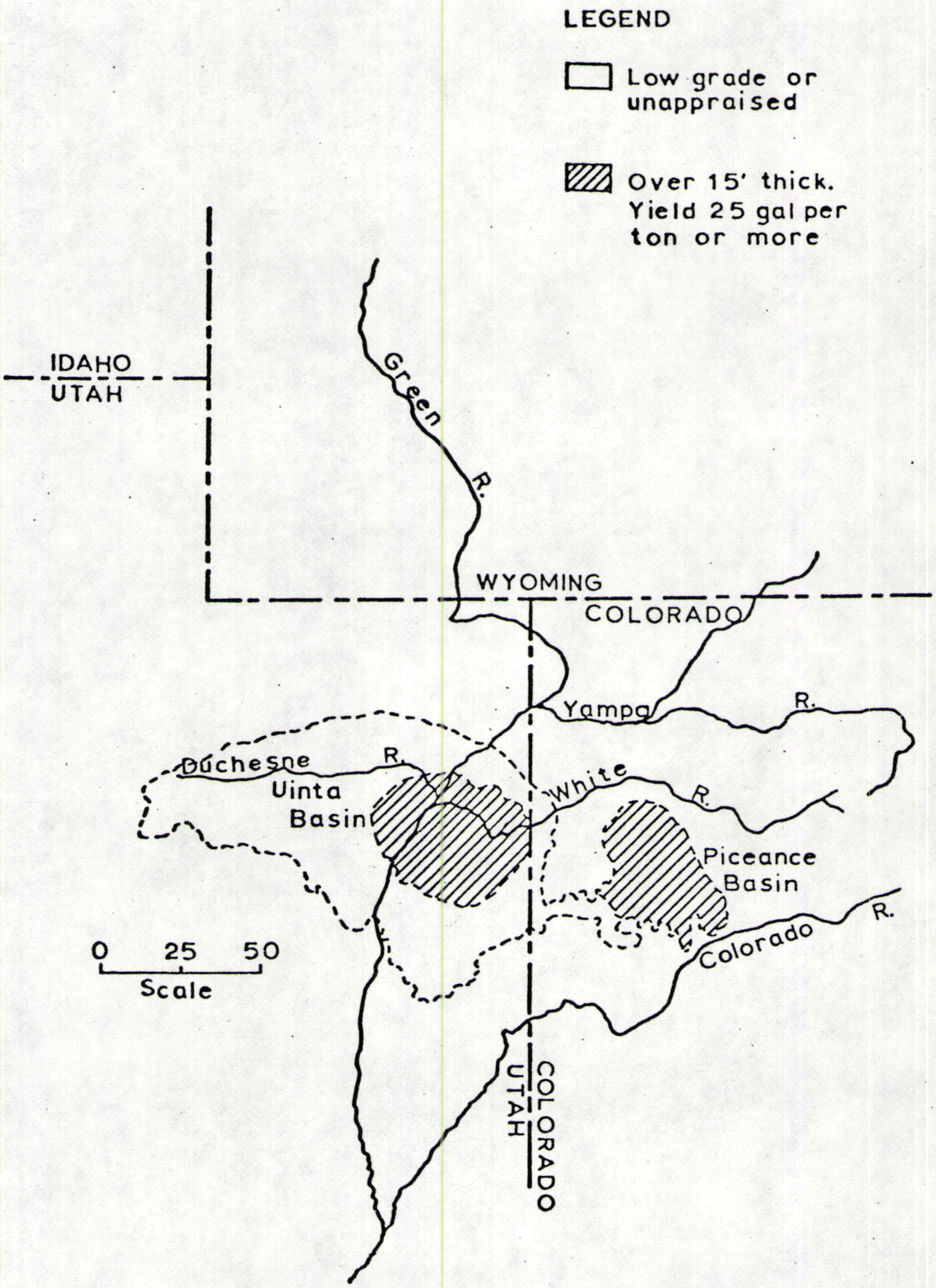
GENERAL DESCRIPTION OF THE BASIN

The White River Basin is located in Colorado and Utah as shown on the following page which also shows the major oil shale reserves in the area. The White River rises in the White River Plateau in Western Colorado and flows west to its confluence with the Green River at Ouray, Utah, about 26 miles south of Vernal, Utah. The White River plateau, is a relatively flat highlying area with elevations generally from 10,000 to 11,500 feet. The average annual precipitation is more than 30 inches in this area. The river receives most of its water supply from this area and then runs westward to the desert rangeland of Western Colorado and Eastern Utah.

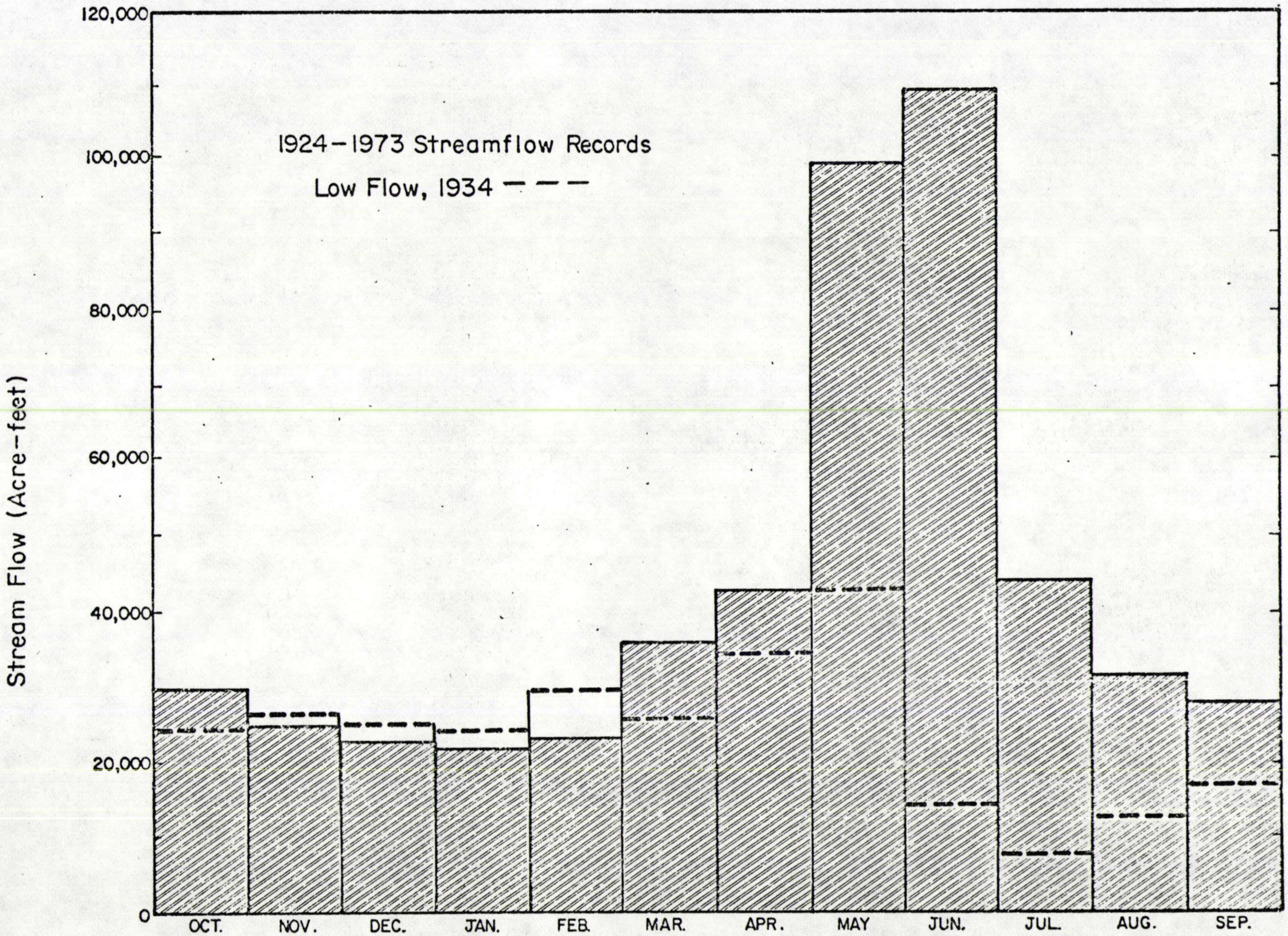
A flow chart of the White River and a mean monthly runoff hydrograph of the White River near Watson are shown on the following pages. Also shown is a graph of the White River discharge weighted mean total dissolved solids for the 1974 water year with and without a simulated reservoir operation.

The portion of the White River Basin in Utah is mostly desert rangeland with elevations near 5,000 feet. This area is semi-arid, characterized by low relative humidity and a wide range of daily temperatures. Mean monthly temperatures vary from near 20° F in January to 75° F in July with daily maximums in the 90's. The mean annual temperature is 48° F.

Precipitation in the Utah portion of the White River Basin averages near 8 inches in the lower elevations and near 10 inches in the higher elevations. The May to October pan evaporation is near 45 inches.

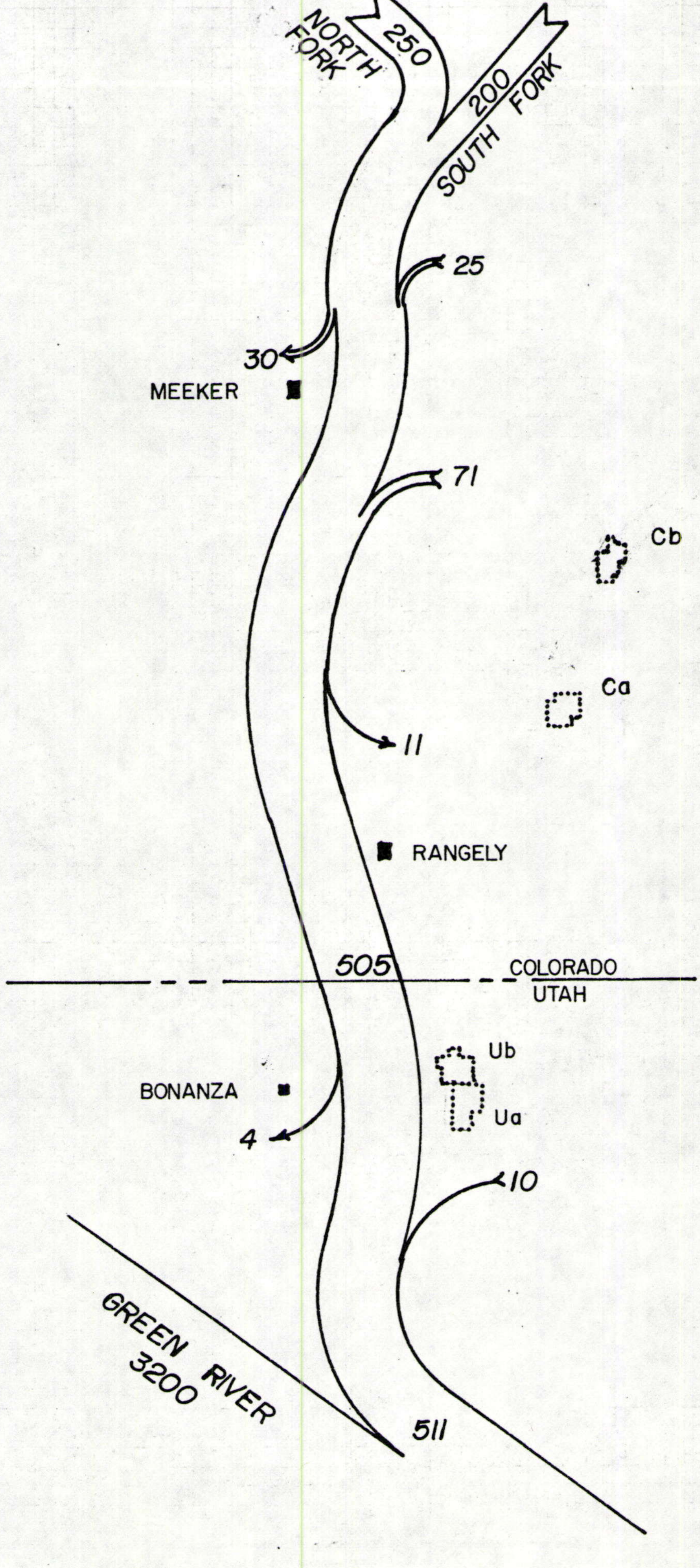


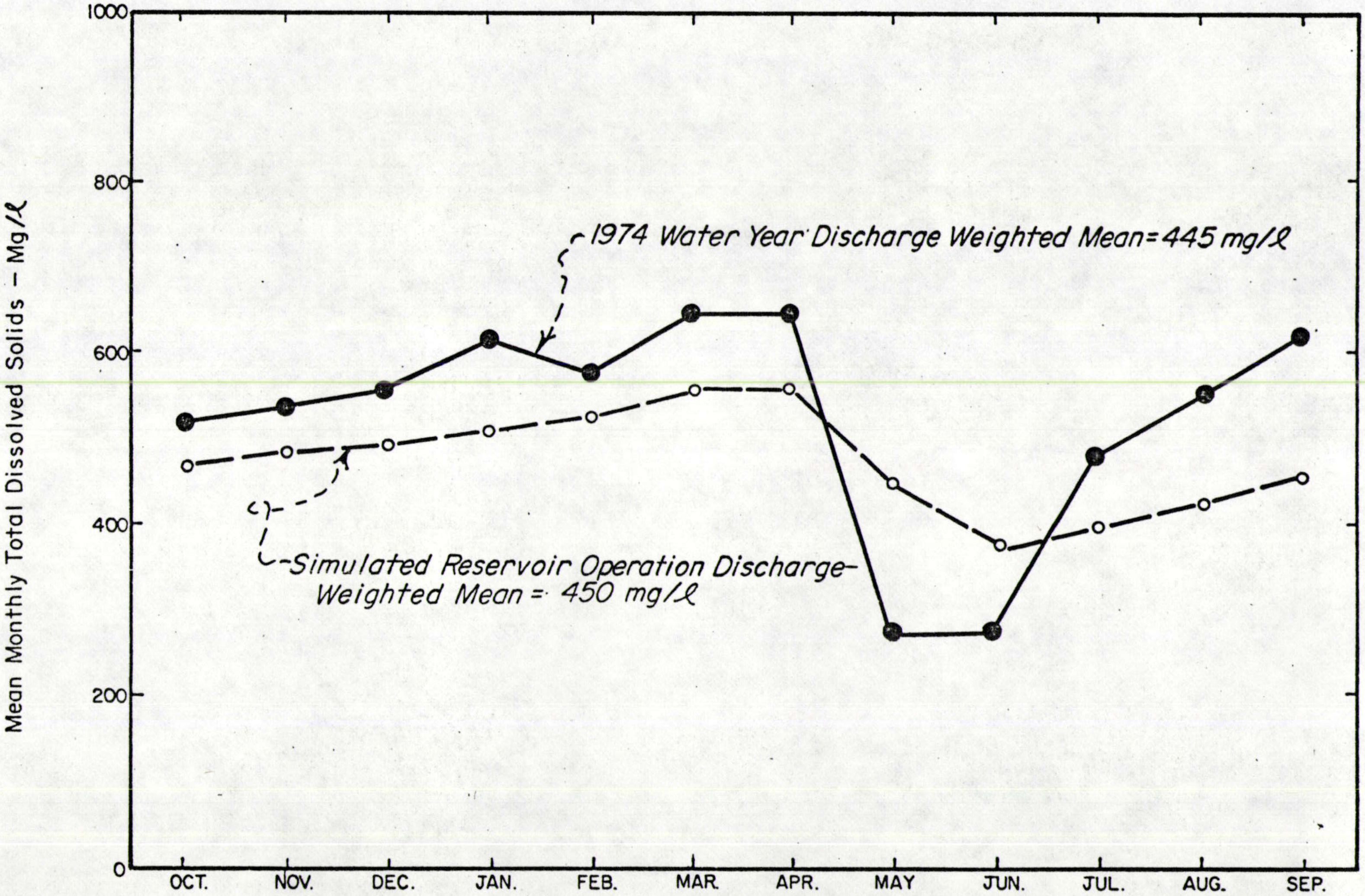
Major Oil Shale Reserves - Uinta and Piceance Basins



Mean Historical Runoff for White River near Watson, Utah

WHITE RIVER FLOW CHART (1000 Acre-Feet)





WHITE RIVER RESERVOIR SITE TOTAL DISSOLVED SOLIDS

Estimates of the range of water required for development of oil shale lease tracts U-a and U-b are shown below. The two alternative sources of water are more than adequate to meet the requirements.

WATER REQUIREMENTS
FOR OIL SHALE LEASE TRACTS U-a and U-b

Minimum Requirement:

Process Plant	9,700 a.f.
Processed shale dust control, irrigation and other undefined uses	1,600 a.f.
Seepage, evaporation & minor losses	1,700 a.f.
Total Practical Minimum Requirement - - - - -	13,000 a.f.

Maximum Requirement:

Minimum Requirement	13,000 a.f.
Add: Raw water to 100% water cooled process and utility plants	8,750 a.f.
Add: Raw water to augment cooling and dust control needs required by different retort processes	4,500 a.f.
Total Probable Maximum Requirement - - - - -	26,250 a.f

WATER RIGHTS

The Colorado River Compact of 1922 divides the waters of the Colorado River as between the Lower Division and the Upper Division, with the dividing point at Lee Ferry. The Compact intended to give the Upper Division half of the River flow at Lee Ferry. However, the Lower Division (Arizona, Nevada, and California) is guaranteed an average of 7.5 million acre-feet annually.

Because the historic flows since 1922 are less than 15 million acre-feet, the Upper Division entitlement is something less than 7.5 million, depending on the water supply. The Bureau of Reclamation now estimates the Upper Basin supply at 5.8 million acre-feet annually under certain operating assumptions.

The Upper Colorado River Basin Compact of 1948 divides the waters of the Upper Basin on a percentage basis. Utah is entitled to 23% and Colorado is entitled to 51.75% of the Upper Division supply. The remaining percentage goes to the states of Wyoming and New Mexico with Arizona getting 50,000 acre-feet per year.

The Upper Basin Compact did not apportion the waters of the White River between Colorado and Utah, nor does the compact appear to offer any procedure to effect an apportionment. Therefore, Colorado and Utah could approve applications from the White River so long as they do not exceed the ceiling provided for in the Compact. Negotiations are now under way between Utah and Colorado in regards to a compact on the White River.

It appears that under the principles which govern the allocation of interstate streams, Utah could assert that it is entitled to an equitable share of the flow of the White River, Hinderlider vs. LaPlata River and Cherry Creek Ditch Co., 304 U.S. 92 (1938). Under this concept each state through which an interstate river flows is entitled to an equitable share of the water from this source.

Neither Colorado nor Utah is presently consuming their full entitlement of water under the Upper Colorado River Basin compact; however, both states are limited in the amount of water they could allocate to oil shale development without seriously curtailing other existing or potential water uses.

It is apparent that with a 500,000 acre-feet annual water supply in the White River at the Colorado-Utah state line, there should be sufficient water remaining in the White River for development in Utah.

A large amount of water has been applied for in relation to oil shale development in Utah and Colorado. However, each state will be required to stay within the compact allocations for water development.

The water right for oil shale development in Utah will require a Utah water right. The water right application held by the Utah Board of Water Resources (No. 36979) is by far the largest applied for in the State of Utah.

The Ute Indian Tribe claims water rights sufficient to irrigate about 13,400 acres of reservation land on the White River and the tribe is currently developing about 3,300 acres of this land. A reservoir on the river to alleviate sediment and ice jamming problems and to control the discharges would enhance the feasibility of increasing this development.

The State of Utah through its state comprehensive water planning program "The State of Utah Water - 1975" recommends that a dam and reservoir be built on the White River to supply water for oil shale development in Utah and for irrigation of Indian lands. It is anticipated that the Utah Board of Water Resources water right application, number 36979, along with Ute Indian tribe Winters Doctrine water rights, would be used for this development.

Segregation and change applications are now being prepared to segregate out sufficient water from the Board of Water Resources application No. 36979 to cover the White River development described in this report. The change application will include the pre-commercial water development phase as required for the White River Shale Project.

DAM SITE INVESTIGATIONS

Site Selection

Several mainstream dam sites, in addition to those studied by the U.S.B.R. and the Utah Division of Water Resources, were selected for preliminary comparative investigation. Based on preliminary cost comparisons, location with respect to oil shale development, and structural competence of the foundation of the dam site, a site located near the center of Section 17, T 10 S, R 24 E, SLB&M was selected for more detailed study. (It should be noted that a site located upstream about 13 miles is an attractive dam site from the standpoint of storage efficiency, but it was not considered for detailed study because it would back water into Colorado and create some flooding of agricultural lands near Rangely.)

Geology

Of the area to be inundated, about 68% is alluvium (Holocene). It consists of unconsolidated silt, sand, and gravel. Thirty percent is of the Uinta Formation (Eocene) and is found on the inclines rising from the river bed. It consists of yellow-gray very fine grained sandstone, yellow-gray siltstone, and gray marlstone. A third exposed formation which stands to be inundated is located in a few isolated spots comprising less than 2% of the total reservoir area. These are terrace deposits (Holocene and Pleistocene). They consist of cobbles and pebbles of gray and tan quartzite and chert in a matrix of fine sand, silt, and clay.

The abutments and foundation materials at the dam site consist of Tertiary age Uinta formation. Here this formation is principally thick to massive bedded light brown, lenticular sandstones which are interbedded with thin beds of lenticular shale, silt, shaley sandstone, and gray marlstone. The bedding strikes north with a dip of 4° - 5° W. Prominent jointing exists in the sandstone beds which joints are spaced about 2-6 feet apart and strike N 70° E with a dip of 85° N, and intersect with joints striking N 60° W with a dip of 80° SW.

These tension joints allow back-sloughing of the slopes aiding in alluvium accumulations at the base of the river escarpments. These deposits coalese with flood-plain and terrace deposits of the White River. Thus the foundation of the dam site is manteled by a layer of alluvium on top of bedrock. Recent drilling has confirmed that the depth of this alluvial fill is 25-40 feet. The stream valley alluvium consists primarily of an upper layer of silts and sands underlain by leticular coarser sands and gravels. These sands and gravels are composed primarily of sandstone and platey shales with some quartzite gravels present.

The left abutment of the site consists of a resistant sandstone bed, underlain by gray, hard marlstone, forming a sharp escarpment about 20 feet high at the edge of the stream valley. The top of this escarpment slopes moderately upward to the south, forming a ravine-cut terrace having a thin veneer of ancient river gravel over it. These gravel deposits appear too thin to be practically excavated and used in dam construction. However, backhoe excavations may reveal some usable deposits.

The left abutment contains a ravine which could provide a channel for an emergency spillway. The bedrock in this ravine consists of interbedded sandstone, shaley sandstone and thin lenticular shale beds. The slope angle from horizontal for this ravine is about 3° in a northerly direction. The bedding dip angle is westerly about 4° in the same area. Sustained periods of large discharge through an unlined spillway utilizing this ravine as a channel could result in backcutting of the slope towards the spillway crest, because of the variable hardness of the rock strata.

The right abutment consists of a steep escarpment rising approximately 220 feet above the river alluvium. The abutment is a highly resistant sandstone with lenticular beds of shales, siltstones, and dolomitic marlstones. From the top of the escarpment the slope is downward to the north.

Site and Topographic Conditions

In the vicinity of the proposed dam site, the flood plain of the White River is defined by near vertical rock abutments arising above elevation 4905. The flood plain is typically 1000 feet wide with the normal river flows confined to a winding channel averaging 100 feet in width in the immediate areas of the dam site. The flood plain vegetation is significant and consists primarily of cottonwood, willows, tamarisk and sagebrush with some grasses. The flood plain alluvium has been deposited to depths 10 feet above the normal river level.

The topography rises to the southwest with slopes of 5% to 10% except for localized erosion cutting and terraces. The vegetative cover on these slopes varies from non-existent in areas of rock outcrops and surface gravels to sagebrush with some minor amounts of grasses. The topography to the northeast is characterized by near vertical sandstone formations rising from the river alluvium up to elevation 5130. The surrounding topography is characterized by sharp escarpments and rock outcrops cut by steep erosion channels. Where the terrace and alluvial deposits will support plant life, it is generally limited to sagebrush and some minor grass cover.

Field Investigation

Subsequent to earlier reconnaissances of the dam site and limited backhoe exploration of potential borrow areas in January, 1975 a drilling program was started in October, 1975 to evaluate the bedrock and alluvial foundation materials. A total of 10 holes were drilled in the foundation and abutments at the site. The coring of the bedrock resulted in recovery of approximately 900 lineal feet of rock core. Angled core holes were drilled into both abutments as well as vertical and angled core holes into the foundation bedrock below the river alluvium. Water pressure testing indicated open joints or cracks in the upper 25 feet to 40 feet of the bedrock. Minor jointing appeared in some of the cores at greater depths but generally water takes were minimal to negligible. Soil sampling of the foundation alluvium was performed in four locations. Sufficient undisturbed samples of the sands and silts were obtained for laboratory testing. Standard penetration tests and split-spoon sampling of all soil strata was accomplished. In the soil sampling holes, the coring of the top twenty feet of bedrock was performed to verify its occurrence. In all holes the water table was found to be coincident with the water surface in the river.

A more complete borrow investigation will be completed as soon as weather permits. The borrow areas in the river alluvium will be further explored as well as the characteristics of two potential borrow

Hydroelectric Power Generation

Development of the proposed White River Dam offers a potential for generating about 20,000,000 kwh per year of electric energy. Preliminary investigations into this possibility indicate that a 5,000 hp turbine-generator unit would be required. Additional study into hydroelectric power generation on the White River is now being made but has not yet been completed. The development plan outlined in this report does not include hydroelectric power facilities.

INDIAN IRRIGATION FACILITIES

Lands currently being developed for irrigation under the Indian lease program are serviced principally by low lift portable pumps which discharge into sediment retention ponds where the coarser sediments are settled out before the water is turned into the canals and ditches. In some cases, headgates and gravity diversions are used during high water to reduce pumping costs. This method of diverting water to the lands along the River flood plain is very effective and most likely the least costly means of getting water onto the land. The pumps are relatively inexpensive and because of the large quantity of sediment pumped their portability makes them easy to repair and to move during the flood-stage of the river.

More costly permanent pump installations will be required to lift water onto the higher bench lands. It is anticipated, however, that upstream storage to provide better flood regulation and reduction of sediment loads will make installation of these permanent facilities feasible. Preliminary estimates of construction costs indicate that the primary water delivery system, not including the distribution system of sprinkler mains and/or sublateral ditches will cost about $345 per acre for the approximately 8,000 acres of land to be served.

The initial phase of the Indian Project consisting of a diversion dam, feeder canal, sedimentation ponds and a supply canal to serve Indian lands in the river bottom would cost $1,250,000.

WATER DIVERSION FACILITIES

A fact summary sheet of the proposed White River Dam and Reservoir is shown on the following page. The pertinent items are discussed in more detail below.

Embankment

The embankment for the proposed White River Dam would be a zoned earth and rock fill structure rising approximately 125 feet above the stream channel. The inner core of the embankment would be constructed from the most impervious materials selected from the borrow areas and the outer shells would be constructed from the plentiful supply of sand and gravels found in the river bottom deposits. The down stream toe of the dam would be constructed from rock material quarried from the spillway excavation and access road on the right abutment of the dam. Freeboard for the embankment would be 10 feet above normal water surface elevation with five feet of freeboard during maximum flood flows. The upstream slope of the dam would be protected with a blanket of rock riprap quarried from the more resistant sandstone beds near the right abutment of the dam.

The cutoff trench for the dam would be excavated to bedrock throughout its length and grouting of the bedrock would be done to minimize seepage through the dam.

Spillway

The principal spillway for the proposed dam would be a reinforced concrete structure having an uncontrolled overflow crest length of 475 feet with a capacity of 17,500 cfs. It would be located over the right abutment of the dam. The spillway would discharge into a stilling basin type energy dissipater from whence the discharge would flow safely into the stream below the dam. An emergency spillway overflow would be created near the left abutment of the dam by depressing the low portion of the embankment 3 feet for a distance of 400 feet. If water were to overtop this section of the embankment it would flow into an enlarged natural channel and exit into the river below the dam.

Outlet Works

The outlet works would consist of two 54 inch diameter steel pipes housed in a 12 ft. diameter reinforced concrete horseshoe shaped tunnel. The tunnel would also be used as a man-way leading to the

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MORE UNIFORM QUALITY

REDUCE FLOOD PEAKS FROM SUMMER FLASH FLOODS - MINIMIZING DISRUPTION TO IRRIGATION SYSTEMS.

valve chamber in the dam as well as provide a water bypass facility for construction. Discharge through the outlet works would be controlled by two 48" diameter cone dispersing valves located on the downstream end of each 54 inch diameter pipe. A shutoff valve or slide gate located on the upstream end of each pipe would be installed for safety purposes. The outlet would have a discharge capacity of approximately 1,300 cfs when the reservoir is full.

Water would be diverted through the dam during construction by utilizing a small coffer dam located approximately 3/4 miles upstream from the dam with a diversion channel leading to the reinforced concrete outlet tunnel. Two seasons would be required to construct the White River Dam and related facilities.

Pumping Facilities

Reservoir pumping facilities would be located on the south bank of the Reservoir. The pumps would be sized to deliver the final selected water demand consistent with the treatment process and cooling requirements. For a minimum delivery of 13,000 acre-feet per year, horsepower requirements could be met utilizing three 500 hp vertical turbine type pumps and one 125 hp pump. Discharge would be into a 30 inch pipeline which would be used to convey water to the oil shale processing facilities. The pumping tower would be a reinforced concrete structure.

COST CONSIDERATIONS

Cost estimates have been made for the proposed White River Dam that indicate the storage facility can be constructed for about $8,476,000, including right-of-way costs. Pumping facilities and non-reimbursible power installation costs are estimated to vary from about $502,000 to $593,000 as the annual water requirement varies from 13,000 acre-feet to 26,250 acre-feet. These values do not reflect the cost of a pipeline to delivery water from the pumping facility to the oil shale processing area.

Annual operation, maintenance and replacement costs, including energy costs are estimated to vary from about $182,000 to $322,000. The following Table summarizes the initial cost, and present value of the annual OM & R costs for water deliveries of 13,000 a.f./hr. and 26,250 a.f./yr. The present value of the OM & R Cost is based on a 20-year period at 8% interest.

Dam Alternative Data

	Annual Water Delivery	
	13,000 a.f.	26,250 a.f.
Initial Cost	9,531,600	9,622,000
Present Value of OM & R cost	1,789,000	3,161,000
Energy requirement kwh/yr.	9,948,000*	19,766,000*

*Potential power generation of dam would be in excess of 20,000,000 kwh per year.

GREEN RIVER-FLAMING GORGE PIPELINE ALTERNATIVE

The second alternative is a single purpose pipeline with the appurtenant pumping facilities to delivery water from the Green River which has been released from storage in Flaming Gorge Reservoir. This alternative would have a minimal environmental impact in that water would be supplied through an existing storage facility, water flows in the Green River would not be significantly altered, the pumping facilities would require a relatively small amount of land and the pipeline would be buried and largely hidden from view. The principal adverse impact appears to be the greater amount of energy required to operate the pumping facilities.

Pipeline Alternative Data

	Annual Water Delivery	
	13,000 a.f.	26,250 a.f.
Initial Capital Cost	10,905,200	17,464,200
Present Value of OM & R Cost	4,145,200	7,738,600
Energy Requirement kwh/yr.	20,410,000	40,814,000